Ocean Color Experiment Ver. 2 (OCE2)

~ Concept Presentation~

Detectors

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Detector Requirements

- **Highest Quantum efficiency: Very high signal to noise ratios (SNR) requirements means the signal resulting from conversion of photons to electrons, needs to be as large as possible.**
- **Low Dark Current: Dark current contributes to the noise in the SNR in an RSS manner. Minimizing the dark current minimizes that contribution.**
- **Wavelengths of interest: Spectral coverage from 350nm to 900nm in 5nm increments. Individual bands at 1245nm, 1640nm, 2135nm for Oceans and 940nm, 1378nm and 2250nm for atmospheric measurements**
- **Individual photodiodes optimized for each of the 144 center wavelengths. Silicon is the detector of choice from 350 to 900nm. The 940nm detector could be either Silicon or InGaAs. The remainder of the IR bands require the use of InGaAs.**
  - To enhance UV performance, the Silicon photodiodes need a thinner dead layer and active thickness. To improve the longer wavelength performance, a thicker active area is required. So one individual detector model cannot be used for all wavelengths. This is already done routinely by the vendors.
  - Standard composition InGaAs with 1.7um cutoff can be used for 900nm, 1254nm, 1378nm, and 1640nm. Strained layer, longer 2.4um cutoff material is required for the 2135nm and 2250, but is a standard product.
  - The anti-reflection (AR) coatings for the Si detectors should be different (optimized) for different sections of the spectrum of interest. The IR detectors are already coated for the narrow band for which they are efficient.

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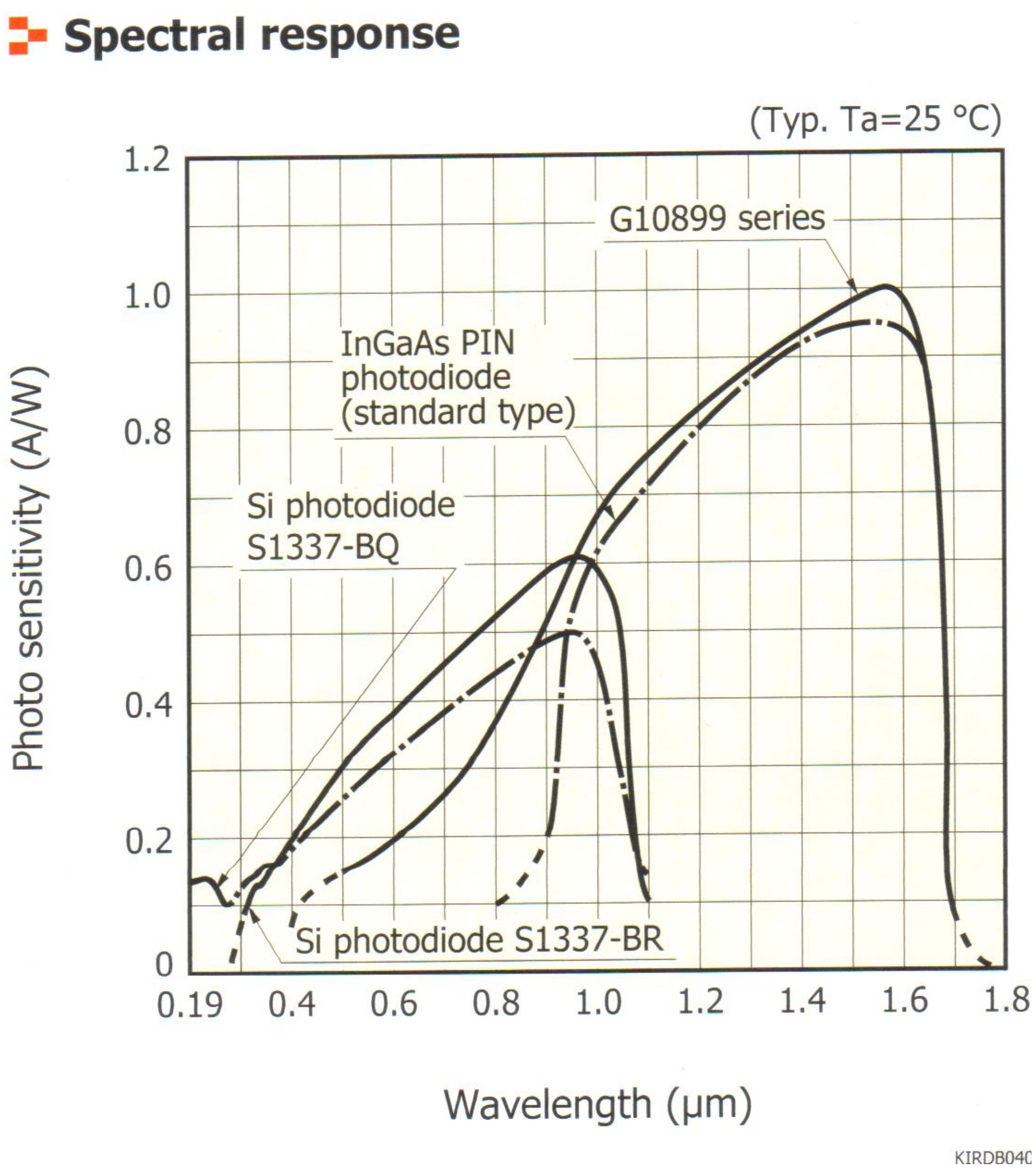
Detector Spectral Response

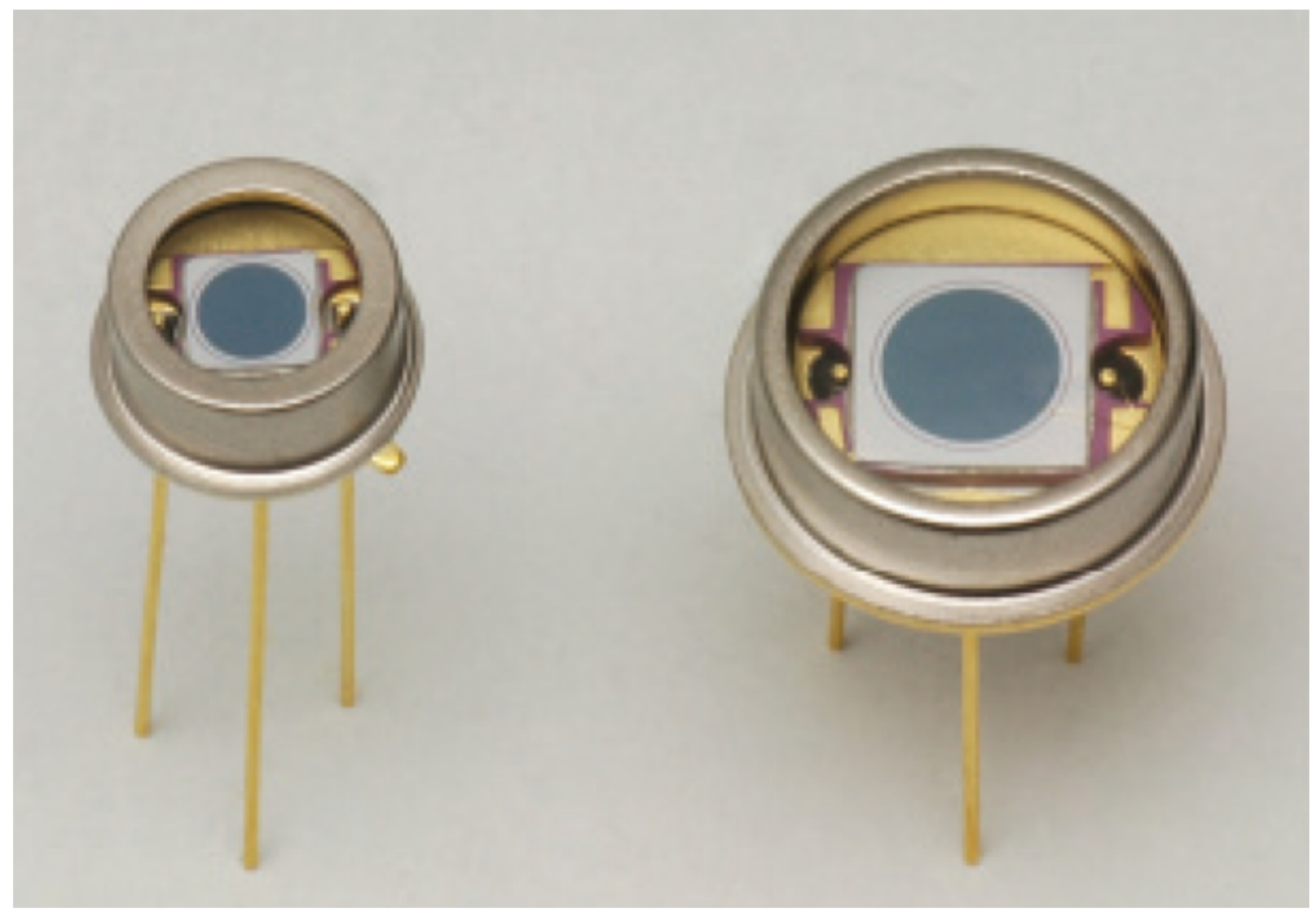
- Comparison of typical Hamamatsu Si and InGaAs photodiodes shows the crossover point at ~950nm so either type could be used at the 940nm band.

- To convert responsivity in A/W to quantum efficiency (electrons/photon), one must convert amps to electrons per second and convert watts to photons per second which is wavelength dependent.



Example Silicon Detectors

- Silicon photodiodes are available in standard TO-5 cans (smaller 9mm diameter). Buy without the window. Some venders can supply a preamp in the package with the detector but these are noisier than what can be tolerated in this application. Unpackaged detector chips could also be procured and mounted directly to the ceramic circuit board to minimize capacitance. Specs below for typical 3mm and 5mm diameter Silicon PIN photodiodes from Hamamatsu.



Electrical and optical characteristics (Typ. Ta=25 °C, unless otherwise noted)

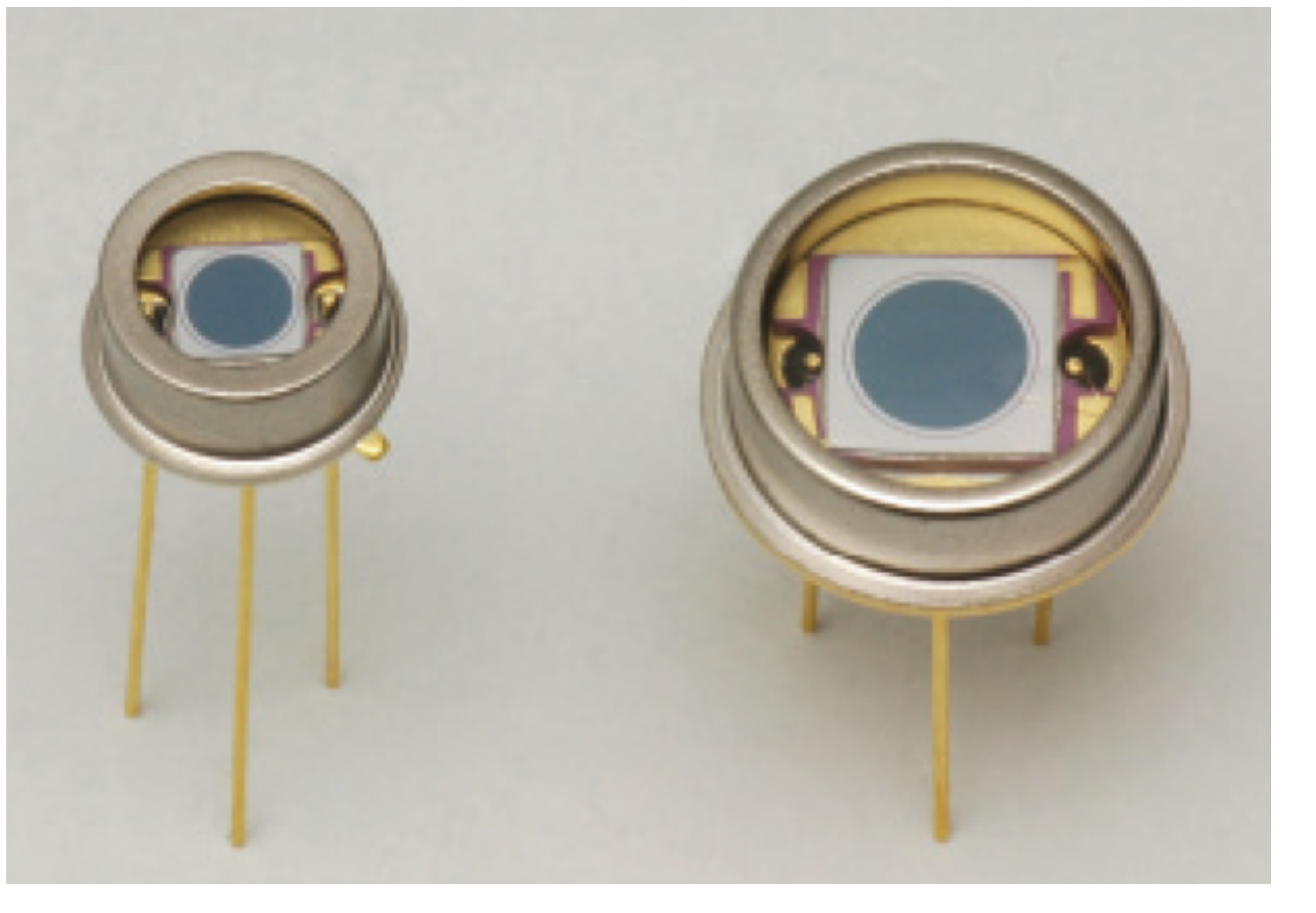
Type No.	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photo sensitivity S (A/W) λp	GaP LED 560 nm	He-Ne laser 633 nm	GaAs LED 930 nm	Short circuit current Isc 100 lx Min. (μA)	Typ. (μA)	Dark current ID VR=10 mV Max. (pA)	Temp. coefficient of ID TCID (times/°C)	Rise time tr VR=0 V RL=1 kΩ (μs)	Terminal capacitance Ct VR=0 V f=10 kHz (pF)	Shunt resistance Rsh VR=10 mV Min. (GΩ)	Typ. (GΩ)	NEP VR=0 V λ=λp (W/Hz^1/2)
S2386-18K	320 to 1100	960	0.6	0.38	0.43	0.59	1	1.3	2	1.12	0.4	140	5	100	6.8×10^{-16}
S2386-18L							4	5.7							
S2386-5K							4.4	6.0	5		1.8	730	2	50	9.6×10^{-16}
S2386-44K							9.6	12	20		3.6	1600	0.5	25	1.4×10^{-15}
S2386-45K							12	17	30		5.5	2300	0.3		
S2386-8K							26	33	50		10	4300	0.2	10	2.1×10^{-15}

* Window material K: borosilicate glass, L: lens type borosilicate glass

Example InGaAs Detectors

Integrated Design Capability / Instrument Design Laboratory

- InGaAs photodiodes are also available in standard TO-5 cans. Buy without the window. Some venders can supply a preamp in the package with the detector but these are noisier than what can be tolerated in this application. Unpackaged detector chips could also be procured and mounted directly to the ceramic circuit board to minimize capacitance. Specs below for typical 0.3mm to 3.0mm diameter Silicon PIN photodiodes from Hamamatsu.



Electrical and optical characteristics (Ta=25 °C)

Type no.	Spectral response range λ (μm)	Peak sensitivity wavelength λp (μm)	Photo sensitivity S λ=0.65 μm Min. (A/W)	λ=0.65 μm Typ. (A/W)	λ=0.85 μm Min. (A/W)	λ=0.85 μm Typ. (A/W)	λ=1.3 μm Min. (A/W)	λ=1.3 μm Typ. (A/W)	λ=λp Min. (A/W)	λ=λp Typ. (A/W)	Dark current ID VR=1 V Typ. (nA)	Dark current ID VR=1 V Max. (nA)	Cut-off frequency fc VR=1 V RL=50 Ω (MHz)	Terminal capacitance Ct VR=1 V f=1 MHz (pF)	Shunt resistance Rsh VR=10 mV (MΩ)	D* λ=λp (cm · Hz$^{1/2}$/W)	NEP λ=λp (W/Hz$^{1/2}$)
G10899-003K											0.3	1.5	300	10	1000		5×10^{-15}
G10899-005K											0.5	2.5	150	20	300		9×10^{-15}
G10899-01K	0.5 to 1.7	1.55	0.15	0.22	0.35	0.45	0.8	0.9	0.85	1	1	5	45	70	100	5×10^{12}	2×10^{-14}
G10899-02K											5	25	10	300	25		4×10^{-14}
G10899-03K											15	75	5	600	10		6×10^{-14}

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Conclusions

- **No technical issues or concerns**
  - Both detector types readily available from multiple vendors
    - Silicon: Hamamatsu, Pacific Semiconductors, Perkin Elmer, Code 553, etc., etc.
    - InGaAs: Hamamatsu, Sensors Unlimited, Discovery Semiconductors
  - No new technology developments required

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